With the Writer's Compliments.

Cerebro-spinal Fever in the Royal Navy (August 1st, 1915—July 31st, 1916)

BY

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CASES OF CEREBROSPINAL FEVER IN THE ROYAL NAVY.—AUGUST 1, 1915, TO JULY 31, 1916.

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The following analysis of the cases of cerebrospinal fever in the Royal Navy during the second year of the war may serve as an addendum to the Report[1] on those occurring during the previous year. Some of the etiological points dealt with at length in the previous Report, such as overcrowding, the spread of the disease by carriers, the influence of influenza and catarrhal affections and of meteorological conditions, and prophylaxis, have not been taken into consideration again. The present Report contains :—

(1) Remarks on the incidence of the cases.
(2) Remarks on some clinical aspects.
(3) A summary of the results of treatment.
(4) A brief history of the outbreaks at various centres.

(1) Incidence of the Cases.

During the year August 1, 1915, to July 31, 1916, there were 104 cases of cerebrospinal fever in the Royal Navy, as compared with 170 cases during the first year of the war. This fall in the number of cases must be correlated with the contemporaneous fall in the incidence of the disease both in the civil population and also in the Army in this country.[1] Although the fall in the general incidence of the disease is probably the main factor in the smaller incidence in the Navy, it should be borne in mind that great care has been taken in prophylaxis, and that in the first half of 1916 bacteriological examination of swabs from the throats of new entries was made at Haslar, Chatham, Plymouth, and at Greenwich of non-contacts (new entries and drafts for sea), in order to detect "carriers" (*vide* pp. 13, 16, 17). Out of 10,852 ratings examined, 298, or 2·7 per cent., carriers were thus detected and isolated. Not only has the incidence been smaller but it has been less widespread; for no case occurred at Blandford Camp or in the Akbar Establishment, in both of which there were a few cases during the first year of the war. At the Deal Depot, which was responsible for twenty-five cases during the first year of the war, there were two cases only in the second year. No case of proved meningococcic meningitis has occurred during the last two years at Osborne or Dartmouth.

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[1] This Journal, 1915, vol. i, pp. 373-407.

The monthly incidence with the results is shown below. As in the first year of the War, the largest number of cases and of deaths occurred in February.

		Cases	Deaths	Recoveries
1915.	August	4	2 or 50·0 per cent.	2
	September	4	3 ,, 75·0 ,,	1
	October	3	1 ,, 33·3 ,,	2
	November	6	5 ,, 83·0 ,,	1
	December	8	4 ,, 50·0 ,,	4
1916.	January	8	3 ,, 37·5 ,,	5
	February	26	7 ,, 26·9 ,,	19
	March	20	6 ,, 30·0 ,,	14
	April	7	2 ,, 28·5 ,,	5
	May	7	0 —	7
	June	3	2 ,, 66·7 ,,	1
	July	8	2 ,, 25·0 ,,	6
		104	37	67

Age Incidence.—Among the 104 cases in the Navy 70, or 67·3 per cent., were under 20 years of age (83, or 79·8 per cent., being under the age of 25 years), and the number of cases progressively diminished in the succeeding decades. The percentage

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For this information I am indebted to Surgeon-Colonel R. J. Reece, H.A.C., of the Local Government Board.

of deaths was lower under 20 years than in any of the succeeding decades. The average age of the 104 cases was 20·4 years, of the fatal cases 22·2, and of the recoveries 19·4 years. The extremes of age were 15 and 46 years.

Age periods	Number of cases and percentage of the total 104 cases	Deaths and percentage in the age periods
15 to 19	70 or 67·3 per cent.	20 or 28·5 per cent.
20 ,, 29	24 ,, 23·1 ,,	12 ,, 50·0 ,,
30 ,, 39	6 ,, 5·8 ,,	2 ,, 34·4 ,,
40 ,, 49	4[1] ,, 3·8 ,,	3 ,, 75·0 ,,
	104	37

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[1] The case which recovered was invalided, and died suddenly six months later, the coroner's inquest finding pneumonia as the cause of death.

In the first year of the war 60·6 per cent. of the cases were under 20 years of age.

Mortality.—Out of the 104 cases 37, or 35·6 per cent., proved fatal; this contrasts favourably with the mortality of 90, or 52·9 per cent., among the 170 cases during the first year of the war.

Ranks and Ratings.—There were two officers—a midshipman Royal Naval Reserve (aged 18), and a surgeon probationer (aged 21), who both recovered. The 102 ratings were as follows: Boys (seamen class) 39 (7 deaths); seamen 22 (11 deaths); stokers 13 (6 deaths); marines 11 (3 deaths); engine-room artificers 5 (2 deaths); officers' stewards 3 (all fatal, average age 20 years); carpenter's crew 2 (1 death); boy servants 2 (1 death); cook's mate 1 (recovery); plumber's mate 1 (recovery); armourer's crew: wireman 1 (fatal); trimmer 1 (recovery); boy artificer 1 (fatal).

(2) REMARKS ON SOME CLINICAL ASPECTS.

Onset.—The mode of onset sometimes varied from the common form characterized by fever, malaise, headache and vomiting. Eight patients when first discovered were in an unconscious condition, and three of these had fallen out of their hammocks; one of these with a graze on the forehead, blood about the nostrils, and vomiting, was regarded for some days as a case of fractured base. Of the eight cases with this apoplectiform onset four proved fatal. In four cases in February respiratory symptoms were so well marked as to suggest pneumonia or acute bronchitis. In one case the prominence of abdominal symptoms gave rise to an initial diagnosis of appendicitis.

In eleven cases at least the disease began very shortly (within three days) after going on leave (six cases), or returning from leave (five cases), and in some instances considerable fatigue must have been entailed by the length of the journeys. In one instance the disease appeared three days after arriving on leave at Gosport from the Grand Fleet. In the five cases in which the disease appeared shortly after returning from leave, the question of infection when on leave arises. In thirteen cases the disease occurred within three weeks of joining the Service and exposure to the trials incident to this change of life. In three cases the disease followed the onset of measles after an interval of about ten days; as these cases were already under observation in hospital, it is improbable that the initial mottled rash of cerebrospinal fever was regarded as measles. In two other cases the disease attacked patients already in hospital, for a lacerated finger and pleurisy respectively. In five cases (four fatal) meningitis, in which the cerebrospinal fluid was proved bacteriologically to contain meningococci, supervened on otitis. In isolated instances drunkenness and head injury (one case), influenza, and vaccination (four cases) immediately preceded the onset. In one case pneumonia and cerebrospinal fever co-existed.

These various factors may have so reduced the bodily resistance as to enable saprophytic meningococci in the nasopharynx to invade the system.

Rashes were recorded in 51, or 49 per cent., out of the 104 cases; in 41 cases the rash was petechial or hæmorrhagic, and 15, or 36·6 per cent., of these proved fatal, a mortality percentage very little higher than that (35·6) of all the 104 cases. In one case with a petechial eruption hæmorrhagic bullæ appeared on the ankles four days after the rash. In five cases there was a macular rash with one death, and in five cases a rose rash with one death. The mortality of the 51 cases with rashes was, therefore, 17, or 33·3 per cent., namely, slightly lower than the mortality of the total 104 cases. In the first year of the War, rashes occurred in 102, or 62·6 per cent., of 163 cases, and the mortality of the cases with rashes was 52 (51 per cent.), or a little lower than that (52·9) of the total 170 cases. Although a very profuse hæmorrhagic rash is extremely ominous, the occurrence of a rash is not necessarily of grave significance. The rash was nearly always noticed on the first or second day of the disease.

Herpes was noted in 21, or 20·2 per cent., of the 104 cases; in 20 cases the herpes was on the lips; in the remaining case it was in the distribution of the nasal branch of the ophthalmic division of the fifth nerve, but the cornea was not affected. In one of the cases with labial herpes there was also cervical herpes. In 14 cases there was also an initial rash; in 2 cases the rash and the labial herpes both occurred on the second day of the disease; in the remaining cases the herpes appeared later than the rash, on an average on the fourth day of the disease, the extremes being the second and the eighth days. In some instances the labial herpes was very profuse. Of the 21 cases 4, or 19 per cent., proved fatal; this mortality is nearly half that (35·6 per cent.) of the total 104 cases, and thus agrees with the ancient belief that herpes in cerebrospinal fever, as in pneumonia, is a good prognostic. In the previous year herpes labialis was noted in 35, or 21·5 per cent., of 163 cases—almost exactly the same proportion as in the present series.

Rarer Manifestations and Complications.—Ocular symptoms. Photophobia, which has been stated to be rare,[1] was noted in 10 cases; conjunctivitis in 5, conjunctival hæmorrhage in 2, panophthalmitis with loss of an eye in 2, strabismus in 8 (5 fatal); ptosis in 3 (2 fatal); nystagmus on the second day in 1 (fatal), and von Gräfe's sign in 1. Hemiplegia occurred in 1 case and weakness of the arm in another case, both of which were fatal; facial paralysis in 1 (fatal), dysarthria in 1 (recovery), and dysphagia in 1 (recovery). Delirium tremens occurred in 2 cases (1 fatal). Pericarditis was noted in 2 cases, both of which recovered. Recent endocarditis was found after death in 1 case (*vide* p. 12), and transient systolic murmurs were heard in 4 cases which recovered. Status lymphaticus was found after death in 1 case. Hæmaturia due to hæmorrhagic cystitis and pyelitis was seen in 1 case, and 1 patient had polyuria for a few days, passing 8, 6 and 4 pints of urine daily, while the temperature was about 103°F. Epididymitis without any evidence of gonorrhœa occurred once.

Synovitis was noted in 4 cases (2 fatal) on the second, fifth, and sixth days of the disease; in 2 cases the knee was affected, in 1 the ankles and wrists, and in 1 the interphalangeal joint of a finger. All the cases had a petechial or hæmorrhagic eruption; this fits in with the view that when purpura and synovitis are associated, the latter is due to hæmorrhages into the synovial membrane. In the case with arthritis of the wrists and ankles on the fifth day of the disease, pericarditis with synovitis of the wrists, ankles and knees developed on the ninth day; in spite of delirium tremens recovery followed. In the first year of the War there were 8 cases (2 fatal) of arthritis. Acute otitis supervened in 2 cases, both of which recovered.

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[1] Foster and Gaskell: "Cerebrospinal Fever," p. 37. 1916: Cambridge.

Relapses during treatment are said not to be uncommon and generally to occur in cases of chronic hydrocephalus which terminate fatally. There was one case proved to be of this nature in a man, aged 19, the relapse which started after nine days of convalescence being ushered in by a rigor. In one case a true relapse or brief second attack occurred seven weeks after the temperature had been normal, and was followed by recovery (*vide* p. 11).

Mixed infections of the cerebrospinal fluid were reported in three cases; pneumococci in one case without any obvious focus; and streptococci in two cases (one an otitic case, in the other infection occurred through the lumbar puncture).

The manifestations of serum disease are dealt with on p. 10.

Diagnosis.—Only those cases in which meningococci were found in the cerebrospinal fluid have been accepted as cerebrospinal fever. In other words, lumbar puncture and examination of the cerebrospinal fluid have been regarded as necessary for diagnosis. This criterion has very probably led to the rejection of some genuine cases of cerebrospinal fever. But no clinical manifestation is pathognomonic of the disease. Thus a hæmorrhagic rash, though highly suggestive, was present in cases proved bacteriologically to be due to other infections, such as pneumococci, or to be free from micro-organisms. The latter group of cases though unsatisfactory must be recognized.[1]

A fulminating case of meningitis with a profuse hæmorrhagic rash occurred on November 7, 1915, in a cadet at Dartmouth. Bacteriological examination of the cerebrospinal fluid, which was almost clear and contained a few red blood cells and occasional polymorphonuclear leucocytes, by Fleet Surgeon H. W. Whiteside, R.N., failed to show any micro-organisms; the cultures were sterile, and no carriers were detected among thirty contacts. There was no necropsy. A brother died in infancy from meningitis believed to be tuberculous.

Cases with meningeal symptoms, which showed meningococci in the nasopharynx but not in the cerebrospinal fluid, have been ruled out, as they may have been meningococcic carriers with meningism due to some other cause. In this connexion it may be pointed out that during the acute stage of cerebrospinal fever swabs from the nasopharynx are often negative. Out of 33 cases of bacteriologically proved cerebrospinal fever meningococci were found in the nasopharynx in 7, or 21·3 per cent., only. This corresponds with von Lingelsheim's figures of 635 cases of cerebrospinal fever with 146, or 22 per cent., positive cultivations from the nasopharynx.[1]

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[1] Among 121 cerebrospinal fluids from cases of meningitis in the French Army, Sacquépée, Burnet, and Weissenbach (*Bull. acad. de méd.*, Par., 1915, lxxiv, 103-105) found six with the features of Widal's "puriform aseptic meningitis" in which no micro-organisms could be found by direct examination or cultivation.

Cerebral symptoms (meningism) accompanying acute infections, such as influenza, pneumonia, enteric, otitis, malaria, may closely imitate cerebrospinal fever, and a certain diagnosis can be made only by lumbar puncture and examination of the cerebrospinal fluid. Even if a patient has signs of pneumonia it is possible, as shown by isolated cases in both the recent epidemics in the Navy, that there is meningococcic meningitis as well.

From other forms of meningitis lumbar puncture and examination of the cerebrospinal fluid constitute again the most reliable method of diagnosis. Even with pre-existing otitis it does not necessarily follow that meningococcic meningitis can be excluded; for, as mentioned on p. 4, in five cases (four fatal) meningitis, in which the cerebrospinal fluid was proved bacteriologically to contain meningococci, supervened on otitis.

Difficulty might arise in the diagnosis from the meningitic form of acute poliomyelitis in which all the symptoms of meningitis may be present, but "on lumbar puncture the cerebrospinal fluid escapes under pressure, is clear, and on cytological examination may be found to contain an increased number of lymphocytes with a normal or sometimes a diminished sugar reaction and an increased amount of albumin" (Batten[2]). An outbreak in Devonshire and Cornwall in 1911 of what was at first thought to be cerebrospinal fever was shown by R. J. Reece[3] to be one of acute poliomyelitis and not one of acute poliomyelitis occurring concurrently with cerebrospinal fever. In July, 1916, there was at Shotley (vide p. 18), an outbreak of fifteen cases with the clinical symptoms of cerebrospinal fever, but four only were proved to be of this nature. Among the remaining eleven cases there was one only which could be regarded as an example of the meningitic form of acute poliomyelitis.

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[1] Quoted in the Report of the Special Advisory Committee upon Bacteriological Studies of Cerebrospinal Fever during the Epidemic of 1915, p. 30.

[2] Batten, F. E.: "Acute Poliomyelitis," p. 68, 1916. John Bale, Sons and Danielsson, London.

[3] Reece, R. J.: "Report of the Medical Officer of the Local Government Board, 1911-12." Appendix A, No. 4, p. 54. 1913.

In acute osteomyelitis of the spine lumbar puncture may give exit to pus from the extradural space. This occurred in two cases in the Royal Navy which will subsequently be published. In neither of these were there definite symptoms of cerebrospinal fever, but Grisel[1] in a review of this form of osteomyelitis states that although in some cases the symptoms of compression are quite definite and disappear when the abscess is evacuated, there are others in which the association with meningitic symptoms and septicæmia renders the diagnosis very difficult.

The sequence of events in the two following cases is, perhaps, worthy of brief mention.

Two brothers from the Fair Isle, Shetland, had measles in September, 1915, in Haslar. One developed cerebrospinal fever thirteen days after the onset of measles and died. The other who had never been well since the attack of measles died in Haslar three months later from tuberculous meningitis. In both cases a post-mortem examination was made.

(3) SUMMARY OF THE RESULTS OF TREATMENT.

Two out of the 104 cases were discovered after death only and, therefore, were not treated for the disease ; 1 case (fatal) received soamin only ; and 6 cases, of which 4, or 66·7 per cent., proved fatal, had lumbar puncture only. Therefore, out of 9 cases which did not receive serum 7, or 77·8 per cent., proved fatal.

Among the 95 cases treated by some form of serum the mortality was 30, or 31·6 per cent. This result, which is in striking contrast to the results of serum treatment in the first year of the War—105 cases with a mortality of 64, or 61 per cent.—fully justifies the serum treatment of the disease, and is compatible with the widely expressed view that the serums employed in this country during the first year of the War were largely deficient in antibodies. Flexner's serum, made under his direction at the Rockefeller Institute, New York, was not available during the first year of the War, but after the failure in this country of anti-meningococcic serum in the epidemic of 1915 the Rockefeller Institute reverted to the manufacture of the serum, and most generously placed a supply of a multivalent serum, made from thirty-two strains, at the disposal of the Royal Navy.[2] Other serums employed during this year, and not in the previous year, are Colonel Mervyn Gordon's various serums and the Pasteur Institute's multivalent serum. In the early part of the second year of the War, when the new serums were not available, Mulford's serum was given in a number of the cases, and throughout the year use was also made of the Lister Institute serum and of Burroughs, Wellcome and Co.'s serum.

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[1] Grisel, P.: *Rev. d'orthop.*, Paris. 1911, 3 sér., tome II, p. 145. For this reference I am indebted to Temporary Surgeon L. Pearce-Gould, M.D., F.R.C.S., R.N..

[2] *Vide* Amoss and Wollstein: "A Method for the Rapid Preparation of Anti-meningitis Serum," *Journ. Exper. Med.*, N.Y., 1916, vol. xxiii, p. 403.

Of the 95 treated with intrathecal injections of serum, 60 did not receive any other form of specific treatment and had a mortality of 18, or 30 per cent., which is a little lower than that (31·6) of the 95 cases. The remaining 35 cases received in addition one or more of the following forms of treatment: hypodermic or intramuscular injection of the serum, of vaccines or of soamin, or hexamine by the mouth, with a mortality of 12, or 34·3 per cent. In 23 out of the 35 cases the additional treatment was the simultaneous subcutaneous (or in a few instances intramuscular) injection of serum; this method was mainly adopted at Plymouth and Haslar; the mortality was 7, or 30·4 per cent. Vaccines were given in 8 cases but did not appear, except perhaps in one or two instances, to exert any decided beneficial effect. The exact figures of the results of treatment are shown in the tabular form below:—

TABULAR SUMMARY OF TREATMENT.

	Cases	Deaths	Recoveries
Antimeningococcic Serum—			
Intrathecally	95	30 or 31·6 per cent.	65 or 68·4 per cent.
Alone	60	18 ,, 30 ,,	42 ,, 70 ,,
Combined with serum hypodermically, vaccines, soamin, or hexamine	35	12 ,, 34·3 ,,	23 ,, 65·7 ,,
Combined with serum hypodermically	23	7 ,, 30·4 ,,	16 ,, 69·6 ,,
Combined with vaccine	4	3 ,, 75 ,,	1 ,, 25 ,,
Combined with vaccine, soamin, and hexamine	1	—	1
Combined with vaccine and hexamine	3	1	2
Combined with soamin	2	1	1
Combined with hexamine	2	—	2
Vaccines—			
(Never alone, always with intrathecal injection of serum), *vide* above	8	4	4
Hexamine—			
Alone	1	1	—
Combined with intrathecal injections of serum, &c., *vide* above	6	1	5
Soamin—			
Alone	1	1	—
Combined with intrathecal injections of serum, &c., *vide* above	3	1	2
Lumbar puncture (only)	6	4 or 66·7 per cent.	2 or 33·3 per cent.
Symptomatic Treatment (only)	2	2	—

More than three quarters of the 95 cases received serum within the first three days of the disease. From tabulation of 1,211 cases Flexner found that when the serum was given within the first three days the mortality rate was 18 per cent., when between the fourth and seventh days 27·3 per cent., and when later than the seventh day 36·5 per cent., and therefore laid stress on the importance of early injection. In the 95 cases treated with serum in the Royal Navy this influence of time can also be seen :—

	Cases	Deaths	Recoveries
1st to 3rd day ..	74 ..	22 or 29·7 per cent. ..	52 or 70·3 per cent.
4th to 7th day ..	15 ..	5 ,, 33·3 ,, ..	10 ,, 66·7 ,,
Later than the 7th ..	6 ..	3 ,, 50 ,, ..	3 ,, 50 ,,
	95 ..	30 ,, 31·6 ,, ..	65 ,, 68·4 ,,

The results obtained by the use of the various brands of serum are shown below in a tabular statement. Flexner's serum was employed in 39 cases altogether, with a mortality of 9, or 23 per cent.; in 27 of the 39 cases it was the only serum used, with a mortality of 6, or 23 per cent.; the 12 other cases in which other serums were given as well showed a mortality of 3, or 25 per cent. The other serums were given in much fewer cases. The mortality percentage of the 14 cases that received Burroughs, Wellcome and Co.'s brand (alone or combined with other serums) was slightly lower than that of the cases treated with Flexner's serum ; and the 16 cases treated by Gordon's various serums alone showed an even lower mortality.

The number of occasions on which serum was given intrathecally varied in the 95 cases from one to eight, according to the duration of the symptoms. In some instances the improvement and fall of temperature after the injection of serum were dramatic.

Sixteen cases received one dose only, and 7 proved fatal, 6 being very acute or fulminating cases ; 25 received two doses of serum (8 deaths) ; 22 cases three doses (7 deaths) ; 8 cases four doses (1 death) ; 11 cases five doses (4 deaths) ; 5 cases six doses (2 deaths) ; 4 cases seven doses (1 death) ; and 4 cases eight doses (no death). In many cases lumbar puncture was performed more often than serum was injected ; in 1 chronic case, in which serum was given six times, lumbar puncture was performed on 20 occasions.

Serum rashes, erythematous or urticarial, were mentioned in 22, or 23 per cent., of the 95 cases treated by serum, but may have been more frequent. The rashes and articular manifestations were practically confined to cases treated with Flexner's and Burroughs, Wellcome and Co.'s brands.

Out of the 22 cases 21 received either Flexner's or Burroughs, Wellcome and Co.'s serum ; 12 had Flexner's serum alone, 2 Flexner's and

Gordon's serums, 1 Flexner's and the Pasteur Institute's multivalent serums, 2 Burroughs, Wellcome and Co.'s serum alone, 1 Burroughs, Wellcome and Co.'s and Gordon's serums, and 3 Flexner's and Burroughs, Wellcome and Co.'s serums (only 4 cases had this combination). The remaining case had 70 c.c. of Gordon's serum, and did not have any manifestations of serum disease except the rash. Out of the 95 cases treated with serum, 41 had Flexner's or Burroughs, Wellcome and Co.'s serum, and among them rashes occurred in 21 or 51 per cent.; whereas among the remaining 54 cases treated by serum there was a rash in one case only. Six of the 22 cases with rashes also had serum hypodermically. The average amount of serum received by the cases with rashes was 65 c.c.; and the average amount received by 14 other cases which had Flexner's or Burroughs, Wellcome and Co.'s serum and recovered was 70 c.c., or practically the same.

TABLE SHOWING RESULTS OF TREATMENT BY DIFFERENT SERUMS.

	Cases	Deaths	Recoveries
Flexner's serum alone	27	6 or 22·3 per cent.	21 or 77·7 per cent.
Combined with other serums	12	3 ,, 25 ,,	9 ,, 75 ,,
	39	9 or 23 per cent.	30 or 77 per cent.
Gordon's serums alone	16	3 or 18·7 per cent.	13 ,, 81·3 per cent.
Combined with other serums	6	3 ,, 50 ,,	3 ,, 50 ,,
	22	6 or 27·3 per cent.	16 or 72·7 per cent.
Pasteur Institute's multivalent serum (3619) alone	9	4 or 44·5 per cent.	5 or 55·5 per cent.
Combined with other serums	5	1 ,, 20 ,,	4 ,, 80 ,,
	14	5 or 35·7 per cent.	9 or 64·3 per cent.
Burroughs, Wellcome & Co.'s serum alone	6	2 or 33·3 per cent.	4 or 66·7 per cent.
Combined with other serum	8	1 ,, 12·5 ,,	7 ,, 87·5 ,,
	14	3 or 21·4 per cent.	11 or 78·5 per cent.
Mulford's serum alone	10	5 or 50 per cent.	5 or 50 per cent.
Combined with other serums	2	1	1
	12	6	6
Lister Institute's multivalent serum alone	11	6 or 54·5 per cent.	5 or 45·5 per cent.

On an average the rash appeared ten days after the first injection of serum. In a case at Haslar which received one injection of 20 c.c. of Flexner's serum in a relapse seven weeks after the primary attack in Egypt, there was within a few hours an "immediate" serum rash. The patient stated that nine lumbar punctures had been performed in the primary attack, but there is no official information as to the administration of serum.

Of the 22 cases none proved fatal, but as the serum rash occurs after an interval of about ten days, the fulminating and acute cases are obviously excluded, and this observation has no prognostic value. Six cases had both herpes and a serum rash; nine cases an initial rash and a serum rash; and three cases an initial rash, herpes and a serum rash (in one case on two occasions); presumably in these instances the skin was especially prone to react.

In some cases pains in the joints without effusion accompanied the serum rash, and in two instances effusion into the joints and a temperature of 102° F. coincided with the rash. In two cases at Chatham temporary deafness occurred at the same time as a serum rash and arthalgia, and was regarded by Temporary Surgeon A. C. MacAllister as a manifestation of serum disease.

Grave accidents due to intrathecal injection of antimeningococcic serum were very rare.

In one case lumbar puncture was done directly after admission to the Royal Naval Hospital, Plymouth, and 50 c.c. of turbid fluid containing meningococci spurted out; 15 c.c. of Gordon's multivalent serum was given intrathecally and the same quantity hypodermically. Respiration stopped at once. The necropsy showed fibrinous adhesions and purulent streaks over the cerebral sulci, with but little exudation at the base of the brain. Both lateral ventricles were distended with blood-stained serum. The purulent exudate over the hemispheres suggested that the illness had lasted a week. In another case at Plymouth lumbar puncture on the third day of the disease gave exit to 30 c.c. of turbid fluid, and 15 c.c. of Gordon's multivalent serum were injected intrathecally; five hours later respiration stopped before the pulse. The necropsy showed fibrino-purulent exudate over the base of the brain and much yellowish fibrin over the pons and medulla, turbid and blood-stained fluid in both ventricles, œdema of the cerebellum pressing on the pons, dilatation of the right side of the heart, and recent and old endocarditis of the mitral valve. Although death did not occur until five hours after the injection of serum, this case resembles the first in the presence of blood-stained fluid in the lateral ventricles of the brain. In a third case death occurred suddenly seven hours after injection of serum and the necropsy showed distension of the lateral ventricles and acute congestion and œdema of the cerebellum pressing on the pons.

In a man who had had six lumbar punctures the site of the punctures became inflamed and death rapidly followed; at the necropsy it was found that the lateral ventricles were greatly distended with pus swarming with streptococci.

In two cases lumbar puncture gave rise repeatedly to severe headache, which was partially relieved when serum was injected intrathecally.

(4) History of the Outbreaks of Cerebrospinal Fever at Various Centres.

The Portsmouth District.

The 28 cases treated at the Royal Naval Hospital, Haslar, were drawn from the Royal Naval Barracks, Portsmouth (14 cases); the Royal Marine Artillery Barracks, Eastney (4 cases); the Royal Marine

Light Infantry Barracks, Forton (3 cases), H.M.S. "Excellent" (2 cases); H.M.S. "Fisgard" (2 cases); and isolated cases from H.M.S. "Amphitrite," H.M.S. "Vernon," and from a torpedo boat. Three of the 28 cases arose in the Zymotic Block at Haslar while under treatment for measles.

In the Portsmouth district the monthly incidence of cases in the Royal Navy was as follows: August, 3; September, 3; October, 2; January, 3; February, 5; March, 9; April, 2; and May, 1. As in the first year of the War the largest number of cases occurred in March.

The early cases were treated by Mulford's serum (5 recoveries, 4 deaths); then 6 cases were given the Pasteur Institute multivalent serum or Gordon's serums (4 recoveries, 2 deaths), and in the later part of the year Flexner's serum alone was given (with 9 recoveries, 1 death). Three cases were not given serum (2 recoveries, 1 death). Staff Surgeon Adshead found that lumbar punctures could be performed without discomfort or struggling under the influence of a hypodermic injection of scopolamine $\frac{1}{100}$ gr., morphine $\frac{1}{6}$ gr., and atropine $\frac{1}{100}$ gr., in 5 minims of water given half an hour previously.

Of the 28 cases 8, or 28·5 per cent., died and 20 recovered; this compares favourably with a mortality of 19, or 52·7 per cent., out of the 36 cases treated at Haslar in the previous year.

Dr. P. Fildes found that out of 603 contacts there were 25, or 4·1 per cent., carriers; that out of 2,022 new entries swabbed there were no positive carriers; and that swabs from 16 cases of the disease were in every instance negative.

The Royal Naval Barracks, Portsmouth.—Out of the 14 cases four occurred between August 28 and September 8, 1915. On August 28, 29, 31, cases occurred in three boys who were in contact with a boy who had the disease in April, 1915, and was found in September to be an obstinate carrier. An isolated case occurred on September 8, and then there were no cases until February 10, 11, 16 and 24. On March 4, a case arose in Haslar Camp in a man who left the barracks on February 28; other cases occurred on March 4, 6, 13, 14 and 27, and the last case occurred on April 23. The total number of cases is practically the same as in the previous year (16).

The Royal Marine Artillery Barracks, Eastney.—The first of the four cases (one fatal) from this depot occurred on February 16, and was so atypical that it was not until March 7 that lumbar puncture was performed and proved that the cerebrospinal fluid, which was clear, contained meningococci. It is perhaps worthy of note that about the same date a similarly atypical case, which was not bacteriologically proved until three weeks after admission, arose in the Royal Naval Barracks, Portsmouth, and that both cases recovered without the use of serum. A fulminating case, fatal within thirty-six hours, occurred on March 8, followed by unconnected and non-fatal cases on March 10 and 26. In the first year of the War there were 12 cases with 6 deaths.

The Royal Marine Light Infantry Barracks, Forton.—Of the three cases borne on the books of these barracks one only arose in the barracks. A boy aged 17 went sick on May 5, in a room with an individual space of 600 cubic feet; the origin of the infection could not be traced. Of the other two cases one was remarkable as presenting a relapse after a long interval; a private went sick with the disease on

January 13, at Alexandria, where he was proved bacteriologically to have the disease and, according to his own statement, was tapped nine times. After February 1 the temperature was normal, and on March 20 he was admitted convalescent to Haslar. On March 22 the temperature rose to 101·4° F., he had a violent headache, Kernig's sign, and lumbar puncture yielded 30 c.c. of turbid fluid under great pressure containing meningococci. He received 20 c.c. of Flexner's (1915) serum, and within a few hours had an "immediate" serum rash. The temperature was normal on March 24 and he made a good recovery. The other case was in a private who left his ship for his home in Gosport five days before he went sick; he never went into Forton Barracks and he might have contracted the disease on the journey from the Grand Fleet.

During the previous year four cases, none of which originated in the Barracks, were reported from this depot.

The Plymouth District.

Twenty-eight cases were reported from this depot, as compared with 30 in the first year of the War. Twenty-seven were treated in the Royal Naval Hospital, Plymouth; the remaining case was in a man who joined the Royal Naval Barracks on March 2, 1916, went on leave two days later, died on March 7 in London, and was found at the necropsy to have cerebrospinal fever. The 28 cases were drawn from the "Impregnable" Establishment (13 cases), the "Powerful" Establishment (7 cases), the Royal Naval Barracks (4 cases), H.M.S. "Cambrian" (2 cases), and H.M.S. "Indus" (2 cases).

In the Plymouth district the monthly incidence of cerebrospinal fever in the Royal Navy was: November, 2; December, 4; January, 2; February, 10; March, 4; June, 1; and July, 1. As in the first year of the War the largest number of cases occurred in February.

In the majority of the cases lumbar puncture was performed under a general anæsthetic by Staff Surgeon D. H. C. Given. The first 7 cases, from November 12, 1915, to January 10, 1916, were treated with the Lister Institute serum (3 deaths); after this Pasteur Institute multivalent serum, Gordon's multivalent serum, or Flexner's multivalent serum were used, sometimes alone, sometimes in combination. Out of 6 cases treated solely with Flexner's serum 1 only proved fatal and in this instance there was a secondary streptococcic infection of the nervous system through the lumbar puncture wound. Of 5 cases treated with the Pasteur Institute's multivalent serum 1 only died; of 4 cases treated with Gordon's multivalent serum 1 proved fatal; of 3 cases treated with both Flexner's and the Pasteur Institute serums 1 died; and of 2 treated with Flexner and Gordon's serums 1 died. Of these 27 cases 19, or 70 per cent., recovered and 8, or 30 per cent., proved fatal. This is better than the 36·7 per cent. mortality in the previous year which was remarkably low for that epidemic. The mortality appeared to be determined by the age of the patients rather than by their treatment; for out of 20 boys from the "Impregnable" (13) and "Powerful" (7) Establishments, none of whom were more than 16 years of age, 2, or 10 per cent. only, died; whereas out of 7 men from the Royal Naval Barracks, H.M.S. "Cambrian," and "Indus" 6, or 85·7 per cent., died; the man who recovered was 26 years of age.

Fleet Surgeon H. C. Whiteside found that out of 2,049 contacts of cerebrospinal fever cases 195, or 9·5 per cent., were carriers; and that out of 2,813 new entries 52, or 1·84 per cent., were carriers. This investigation referring to the first half of 1916 forms the subject of a report by Fleet Surgeon H. C. Whiteside.

In *the "Impregnable" Establishment* the first case occurred on November 12 in "Impregnable I" and proved fatal. Cases then occurred in "Impregnable III" on November 25, December 2 (fatal), 4, and 8, the last two being from the same mess. On December 14 a case occurred in "Impregnable IV" (late "Circe") in a boy who had communication with "Impregnable III." After an interval of seven weeks 3 cases occurred in "Impregnable I" on February 4 and 12 (a case). On February 23 a case appeared in "Impregnable III." After this isolated cases arose in "Impregnable III" on April 21, and in "Impregnable I" on June 8 and July 23. The last case was of rather special interest as the cerebrospinal fluid contained pneumococci as well as meningococci. There was a hæmorrhagic rash, herpes of the nasal branch of the ophthalmic division of the fifth nerve, no evidence of pneumonia, and recovery. The number of cases (13) is larger than during the first year of the War (9), although, from figures kindly provided by Fleet Surgeon L. E. Dartnell, the individual cubic space is now greater than it was a year ago.

The "Powerful" Establishment, which had 2 cases in 1914, and 2 cases in the first year of the War, both on April 10, 1915, in "Powerful I," had 7 cases between February 1 and April 29, 1916. Six cases occurred in "Powerful I" on February 1, 18, 19, March 29, April 2 and 29. One case arose in "Powerful II" on February 4. The increased incidence of cerebrospinal fever in "Powerful I" is due to some undetected factor, for the hygienic conditions have improved since the first year of the War; the upper parts of the doors in the casemates, which are used for classes, have been perforated, thereby increasing the ventilation. The upper deck was roofed over and boys slept there since January 21, 1916; in this way 100 additional cubic feet per boy was obtained, and the incidence of catarrhal fevers forthwith diminished. Nevertheless cerebrospinal fever began on February 1.

The Royal Naval Barracks, Devonport.—A fulminating case occurred on March 22, 1916, followed on March 30 by a case which recovered, and on April 2 by a case which proved fatal with a secondary streptococcic infection from the lumbar puncture (*vide* p. 12). None of these cases had been in contact with cerebrospinel fever patients or with previously recognized carriers. As mentioned above a man attached to this depot died in London of cerebrospinal fever but was in the barracks for two days only. In the first year of the War there were fifteen cases in this depot.

In the "Cambrian" two cases occurred among the stokers on January 10 (a fulminating case) and 30. No cases occurred here during the first year of the War.

In the "Indus" two cases occurred among the engine-room artificers on February 7 and 29. During the first year of the War there were two cases here.

At the *Marine Light Infantry Barracks, Devonport*, no cases occurred. In the first year of the War there were three cases.

Chatham District.

The 18 cases reported were drawn from the Royal Naval Barracks (14), the Royal Marine Light Infantry Barracks (2), and H.M.S. "Egmont" (2), and were treated at the Royal Naval Hospital, Chatham.

The monthly incidence of cases in the Royal Navy in the Chatham District was as follows: November, 1; December, 3; February, 6; March, 6; April, 1; May, 1. In the previous year the largest number of cases occurred in February. During March, 1916, there was an outbreak of the disease among the soldiers in the district.

The treatment of the cases was described by Temporary Surgeon W. H. W. Cheyne,[1] who insisted on the importance of early and frequent injection of mixed serums and of anæsthesia for lumbar puncture and the administration of serum.

Of the 18 cases 9, or 50 per cent., proved fatal; this is an improvement on the mortality of 16, or 76 per cent., out of the 21 cases during the first year of the War; but it is much above the percentage mortality (35·6) for the whole 104 cases in the Royal Navy during the second year of the War. In this connection the following points should be taken into consideration: Two of the fatal cases were complicated with otitis (1 with a large perforation of the tegmentum tympani into the cranial cavity, the other with thrombosis of the cavernous sinus), which appeared to be the lethal lesion; and 3 other fatal cases had one dose only of the Lister Institute serum. Of the remaining 13 cases treated with serums 4 (1 with delirium tremens), or 31 per cent., proved fatal. Of the 9 recoveries, 4 were invalided (2 having lost an eye).

Staff Surgeon S. F. Dudley found that out of 2,548 new entries (March to July, 1916, inclusive) swabbed, 58 or 2·23 per cent., were positive carriers.

Royal Naval Barracks.—The first case occurred on November 28 in a boy servant who had already been fourteen days in a medical ward of the Royal Naval Hospital for right-sided pleurisy. The second case, in a second-class stoker, returned from leave with symptoms of two days' duration on December 4. The third case, in a seaman, aged 37, one of otitis with thrombosis of the cavernous sinus, went sick on December 5, and was bacteriologically proved to be meningococcic at the necropsy only. No further case occurred until February 6, when a seaman, aged 28, had a sharp attack of the disease from which he recovered; it is interesting to note that in July, 1915, he had high fever and meningitic symptoms in the Royal Naval Hospital, Plymouth, where lumbar puncture was done and normal cerebrospinal fluid withdrawn. He had a strongly positive Wassermann reaction, and recovered under anti-syphilitic treatment. On February 17 an officer's steward, third class, who had been in the service nineteen days, went sick. On February 22 a second-class stoker developed the disease, and on February 23 a cook's mate went sick. A close contact of the case on February 22 showed signs of the disease on February 27. Then there was an interval until March 13, when 3 cases occurred among second-class stokers, followed on March 23 by a seaman R.N.R. On March 25 another second-class stoker went sick with the symptoms of the disease, and died when on leave, but as bacteriological examination was not available, he is not included as a case. A fulminating case in an officer's steward, third class, occurred on

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[1] JOURNAL OF THE ROYAL NAVAL MEDICAL SERVICE, 1916, vol ii, pp. 325-328.

April 2; and the last case, in a second-class stoker, began on May 30. Thus, out of 14 cases, 8 were among stokers second-class.

In the "Egmont" 2 cases occurred on March 24 and 25 in a midshipman and a shipwright.

At the *Royal Marine Light Infantry Head Quarters* 2 isolated cases occurred on December 1 and February 17.

Crystal Palace.

At this depot between December 28, 1915, and July 1, 1916, there were 8 cases with a mortality of 2, or 25 per cent., as compared with 33 cases and 21 deaths (63·6 per cent.) during the first year of the War. This fall in the incidence of the disease has followed improvement in the hygienic arrangements at the Crystal Palace. The cases were again treated at Croydon Borough Fever Hospital, the Resident Medical Officer of which kindly supplied information about the cases.

The first case occurred on December 28, 1915, at a time when catarrh and mild influenza were prevalent, and was at first regarded as enteric fever. In January, 2 cases occurred on the 24th and 31st; in February, there were 3 cases on the 2nd, 5th and 20th. Isolated cases occurred on June 5 and July 1. These cases all received Burroughs, Wellcome and Co.'s serum; 5 also received a stock vaccine (Parke, Davis and Co.), 6 hexamine, and 3 soamin.

Fleet Surgeon P. W. Bassett-Smith, C.B., found among 46 contacts 3, or 6·12 per cent., positive carriers, and among 4,233 non-contacts (new entries, and drafts for sea who had already done service or had completed their training) examined during the first six months of 1916, 45 carriers, 37 of which occurred in March (8), April (20), and May (9).

Shotley Training Establishment.

There were 11 cases with 4 deaths, or 36·5 per cent., between November 16, 1915, and July 29, 1916, as compared with 7 cases (5 fatal) in the first year of the War. In addition a surgeon probationer (from H.M.S. "Lydiard") was treated in the hospital and recovered.

The first case occurred on November 16, 1915, in a boy who had been in hospital with otitis media and perforation of the drum for twelve days, and was convalescent when symptoms of meningitis arose and lumbar puncture showed that meningococcic infection was present. On November 19 there was a second case, also fatal. No more cases occurred until February 8, 1916, when a boy with otitis passed through an attack of cerebrospinal fever. Seven weeks later on March 31 there was another case in a boy who rapidly recovered, but had a relapse on May 21. Cases also occurred on May 8, 23, and on June 15. After four and a half weeks' interval there was a sudden outburst of cases with the clinical symptoms of cerebrospinal fever in July. Of 15 cases 4 were bacteriologically proved to be due to meningococcic infection. The first positive case occurred on July 19 in a boy who had been in the Service fer one week and had been vaccinated six days before the onset of symptoms. A second proved case of cerebrospinal fever occurred on July 21 in the same dormitory (No. 7) which had an individual cubic space of 600 feet; this patient had joined two and a half weeks previously and had been vaccinated a week before the onset. Two other cases not bacteriologically positive occurred in the same dormitory on July 20 and 21. A third case of cerebrospinal fever arose on July 21 in another dormitory; this boy had joined the Service the day before and had not been vaccinated. A fourth case occurred on July 29.

Of the 11 cases not proved bacteriologically to be meningococcic, the records of the cytological examination of the cerebrospinal fluid are available in 5 cases; in 2 there was an excess of lymphocytes over polymorphonuclears; neither of these cases showed any subsequent paralysis, and so cannot be regarded as examples of the meningitic form of acute poliomyelitis; further, as there was one case only of mumps during July at Shotley, it is improbable that the meningitis was a complication of that disease. In 1 case the lymphocytes and polymorphonuclears in the cerebrospinal fluid were present in about equal numbers. In 2 cases the polymorphonuclears were in excess of the lymphocytes; in one of these cases there was transient and slight weakness of one leg. Four other cases had persistent headache, 2 showing mental disablement. One case, the cytological report of the cerebrospinal fluid of which is not known, was left with weakness of the right leg, loss of the knee-jerk on that side, tenderness of the posterior tibial nerve, and weakness of control of the bladder. This appears to be the only one of the 11 cases which could be regarded as an example of the meningitic form of acute poliomyelitis. Dr. G. I. P. Stewart, Medical Officer of Health for East Suffolk, has kindly informed me that no contemporaneous outbreak of acute poliomyelitis or of cases of a similar doubtful nature was reported in the county.

Ten cases were treated by intrathecal injection of Gordon's multivalent serum after washing out the spinal cord with 0·5 per cent. of carbolic acid in saline solution as suggested by Captain Sheffield Neave, R.A.M.C.(T). of Ipswich. This method of treatment appeared to be beneficial and certainly no bad effects were ascribed to it.

Deal.

At the Marine Depot 2 cases occurred on January 31 and February 15, both of which recovered. In the first year of the War 25 cases (with 8 deaths) originated at this depot.

Cases in Sea-going Ships.

Ten cases were reported from sea-going ships, but in no instance did more than 1 case arise in the same vessel, a most satisfactory result. The cases occurred in the "Campania" (August 6, 1915), "Torpedo Boat No. 110" (September 9), a mine sweeper "St. Elvies" (September 28), "Shannon" (October 13), "Defence" (November 5), "Bristol" (May 3, 1916), "Conqueror" (May 5), "Royal Oak" (May 23), "Lydiard" (July 8), and "Malaya" (July 27). There were 5 deaths. The average age of all the cases was 23·7 years, of the fatal cases 25·2, and of the recoveries 22·2 years. The high mortality is perhaps explained by the delay that may necessarily occur in obtaining serum treatment. In the first year of the War there were 12 cases with 8 deaths; in only one ship was there more than one case. Thus during the first two years of the War out of 274 cases of cerebrospinal fever 22, or 8 per cent., cases with 13 deaths, or a percentage of 59, occurred in sea-going ships.

In addition to the medical officers incidentally mentioned I beg to express my sincere thanks for courteous help and information to Deputy Surgeons-General H. W. G. Doyne and R. Hill, C.V.O.; Fleet Surgeons W. H. S. Stalkartt, F. Fedarb, M. Rodd, T. D. Halahan, J. A. Campbell, C. J. E. Cock, W. L. Martin, E. A. Shaw, Staff Surgeon L. Warren, and Temporary Surgeons W. H. Watson Cheyne, and E. J. Tongue.